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Original citation & hyperlink:
Palmer, A.R. and Bennett, J. (2013) Degradation of communal rangelands in South Africa: towards an improved understanding to inform policy. African Journal of Range and Forage Science, volume 30 (1-2): 57-63.
http://dx.doi.org/10.2989/10220119.2013.779596

Degradation of communal rangelands in South Africa: towards an improved understanding to inform policy.

Journal:	*African Journal of Range & Forage Science*
Manuscript ID:	TARF-2012-0053.R2
Manuscript Type:	Original Article-research notes, research papers
Keywords:	Rehabilitation, Communal rangelands, Social systems, Invasive plants - indigenous, Land degradation
Abstract:	In South Africa, the relative extent of range degradation under freehold compared to communal tenure has been strongly debated. We present a perspective on the processes that drive rangeland degradation on land under communal tenure. Our findings are based on literature as well as extensive field work on both old communal lands and 'released' areas, where freehold farms have been transferred to communal ownership. We discuss the patterns of degradation that have accompanied communal stewardship, and make recommendations on the direction policy should follow to prevent of further degradation and mediate rehabilitation of existing degraded land.

Introduction

Natural rangelands, comprising most un-cultivated landscapes in the arid and semi-arid regions of the world, support livelihoods through the provision of a range of goods and services (Reid *et al.* 2008). Livestock production is one of these services, occurring as extensive ranching under freehold tenure or collective ranching on land under communal tenure (Reid *et al.* 2008). Land degradation is a threat to the productivity of these systems, with an estimated cost of US$40 billion annually (FAO 2010), and in this paper we further develop the degradation theme introduced earlier in this volume (Vetter 2013). The definition of land degradation has moved beyond the biophysical (vegetation change and soil loss) and is now considered as '…. a reduction in the capacity of land to perform ecosystem functions and services that support society and development' (FAO 2010). In addition, it is considered to have taken place when the landscape functionality declines to a point where water and nutrients are no longer controlled effectively by the landscape (Tongway and Ludwig 1996) and are lost to rivers. Considerable debate still remains around the extent to which land degradation is occurring under different management and land tenure systems and what the main drivers of degradation are (Ellis and Swift 1988, Rowntree *et al.* 2004). Vetter (2013) suggests that communal rangelands are judged to be degraded based on several indices (species composition and standing biomass) which compare neighbouring communal and commercial properties. We elaborate further on this view, and attempt to develop the argument for using indices that provide a perspective on the functional attributes of rangelands.

Although land degradation is recognised under both communal and freehold tenure systems (Hoffman and Cowling 1990, Lloyd *et al.* 2002) in southern Africa, much of the debate has focused on land managed under common property arrangements. Degradation in South African communal areas can be attributed in part to the inability of land users to respond decisively to environmental clues which warn of impending state changes, but is also blamed on other drivers including the skewed access to resources which accompanied the social engineering before 1994 (Beinart 2000) and to inappropriate policy frameworks (Vetter 2013). Ostrom *et al.* (1999) show that collective action for management of common pool resources is possible and that this can facilitate sustainable resource management by linking social with ecological systems to build resilience (Berkes and Folke 1998). Linked to this has been protracted debate regarding the degree to which rangeland change is driven by biotic or abiotic factors. Of particular focus has been the ecological dynamics of semi-arid rangelands as inherently non-equilibrial systems, which are primarily driven by abiotic factors such as rainfall, and the influence this has on vegetation dynamics in the shorter term (Behnke and Scoones 1993). Whilst there is ample evidence to uphold the assertion that rainfall is a key driver of rangeland vegetation dynamics (Wiegand *et al.* 2006, Fensham *et al.* 2009), there is also clear empirical data supporting animal-induced vegetation change and the emerging consensus is that semi-arid rangelands may exhibit a variety of equilibrial and non-equilibrial responses at different temporal and spatial scales (Vetter 2005), particularly during dry periods when feedback between plants and animals is likely to be most apparent (Illius and O'Connor 1999). Moreover, in the longer term, the influence of several other edaphic variables such as elevated [CO_2], increased surface temperature (Hoffman *et al.* 2011), and reduced potential evapotranspiration (Eamus and Palmer 2007) on vegetation change, cannot be ignored. Elevated [CO_2], for example, may impact on increasing success of C3 trees and shrubs relative to grass (Scholes and Archer 1997, Bond *et al.* 2003) and affects all tenure regimes.

In South Africa, the degradation debate is polarised between extensive freehold farms, and collective livestock production in traditional villages. The communal rangelands are concentrated in the former homeland areas, which constitute about 13% of the land surface area but are home to 25% of the human population and hold about half of all livestock (Scogings *et al.* 1999). As a direct result of the political history, there are three categories of communal rangeland in South Africa. Firstly, designated rangeland in communal areas that were established as 'native reserves' during or before the 1913 Land Act, and additions to this as part of the Native Trust Land Acts of the 1930s. Secondly, there are now rangelands that were recently commercial (freehold) farms that were transferred as part of homeland consolidation or more recent (post 1994) land redistribution. Thirdly, the arable lands that are either abandoned (and thereby effectively a permanent extension of the range) or are still in use and become a common grazing resource after harvest, with crop residues providing grazing during the dry season. This phenomenon of using the cultivated lands as part of the grazing resource is prevalent in many areas under communal tenure but is particularly noticeable in countries such as Lesotho where there are no fences, and during the dry season herders actively focus their livestock on these resources. In regions such as the former Transkei and Ciskei (now part of the Eastern Cape, South Africa), where there is an general absence of active herding, and poorly maintained fences, livestock wander freely onto both cultivated and abandoned areas and these areas represent a significant resource available to graziers in the dry season.

There is a long history of communal grazing within many of these areas as well as associated claims of land degradation. The first official reports of land degradation in the form of overgrazing and soil erosion were recorded during the 1880s in the Herschel district of Ciskei (Bundy 1988) and by the 1920s such reports were widespread in both the Ciskei and Transkei (Beinart 2003) where only common property tenure prevails. Several studies report on components of land degradation on common property, including reduced productivity (Wessels *et al.* 2004), increased soil erosion (Kakembo and Rowntree 2003), change in the composition and basal cover of vegetation (Vetter *et al.* 2006, Anderson and Hoffman 2007, Todd and Hoffman 2009) and increases in woody shrubs (Shackleton and Gambiza 2008). This trend in degradation has been attributed to several drivers, including high livestock populations; an absence of conventional grazing management practices such as rotational grazing and resting; limited access to markets (Palmer *et al.* 1999); poverty (Meadows and Hoffman 2002); and that livestock populations are increasingly being maintained by external inputs which has a direct effect on secondary productivity (Vetter 2007).

Here we define degradation as a deleterious change in the rangeland for livestock production, encompassing a range of changes, including species composition with a shift from desirable (to livestock) to unpalatable or toxic species; a general reduction in standing biomass and associated leaf area; a decline in basal cover of perennial grasses; an increase in woody shrubs; and an increase in soil erosion. Under continuous grazing and trampling in the eastern coastal regions of South Africa, the hardy, perennial, tough lovegrass (*Eragrostis plana),* can replace palatable leafy grasses (e.g. *Digitaria eriantha* and *Themeda triandra*) through preferential selection of the latter by cattle (O'Reagain and Grau 1995).

Variation in degraded states with lithology and land-use history

Rangelands may have different vegetation trajectories when compared to one another, with adjacent rangelands, with comparable climate regimes, displaying considerably different vegetation end-points (Vetter 2013). This is confirmed by research in the former Transkei (Finca 2012), where, following continuous grazing on acidic soils derived from dolerites and sandstones, rangelands become dominated by high biomass, less palatable grasses such as *Eragrostis plana, Elionurus mutica, Hyparhennia hirta* and *Sporobolus africanus*. This state is still useful to graziers, with a higher grass biomass, basal cover and net primary production than a topographically-paired adjacent catchment. The adjacent catchment (Figure 1) is on Karoo Supergroup rocks (mudstones) and the rangeland has a lower standing biomass, leaf area index, basal cover and NPP (0.49 kg C m^{-2} y^{-1} versus 0.74 kg C m^{-2} y^{-1}). The difference in the current condition of these two topographically paired catchments is an example of the different end-points which can be achieved under the same topographic, climatic and management regime, with perceived indices of degradation being much higher in the latter than the former catchment.

Degradation is seldom driven exclusively by continuous or excessive herbivory, but several other processes happening under continuous livestock grazing also contribute to vegetation shifts. These include the concentration of nutrients by livestock near the homesteads as a result of kraaling, and along the drainage lines (Augustine and McNaughton 2004). Livestock behaviour, when combined with high livestock numbers under communal management, results in localized effects such as excessive trampling along footpaths and around water points. The concentration of nutrients, particularly nitrogen, around homesteads and water points, results in short, perennial grazing lawns, dominated by *Cynodon dactylon*, which are not leafy but provide good grazing for sheep. These grazing lawns have been described elsewhere (Augustine and McNaughton 2004), and are prevalent in wildlife-dominated systems where species such as blesbok and black wildebeest are known to create and maintain lawns. During the wet season, the active green growth of these lawns is clearly visible in high resolution infra-red imagery (Palmer and Fortescue 2004). Predominance of grazing lawns in a landscape, which occurs when degradation progresses, reduces the range of options available to graziers during the dry season when forage on the grazing lawn is depleted.

Functional considerations in degraded landscapes

Degradation can also to be viewed as a change in the efficiency of water use by the landscape (le Houerou 1984, Holm *et al.* 2003). Using models developed from the MODIS programme (e.g. NPP (Running *et al.* 2004) and ET (Mu *et al.* 2011)), we can now compute water use efficiency of rangelands in different condition classes and explore how water use efficiency changes with degradation. Capture of carbon and evapotranspiration are driven primarily by the leaf area index (LAI) of the canopy (Law *et al.* 2002), and under very high stocking rates, many rangeland types under common management have both low standing biomass and low LAI. This equates to a landscape that does not optimally use and control the available precipitation to assimilate carbon, and results in high water yield through greater run-off and storm flow events. When the LAI is low, water leaves the landscape and it is not used to drive local evapotranspiration and therefore production. The exception to this is the case of the grazing lawns (Augustine and McNaughton 2004), where short green grass provides good grazing during the growing season but does not allow the grazier to accumulate leaf material to attenuate the effect of forage shortage during the dry season.

In many southern African rangelands, woody encroachment remains a serious challenge (Moleele *et al.* 2002, Shackleton and Gambiza 2008, Bennett *et al.* 2012). Many taxa, including several species of the genera *Acacia, Dichrostachys, Elytropappus, Euryops, Leucosidea, Passerina, Pteronia* and *Searsia (=Rhus),* are known to have a deleterious impact on the forage potential of rangeland. Although these woody shrubs do provide other ecosystems services such as woodfuel, biodiversity, carbon sequestration and rain-drop interception, in general their increase reduces the options for graziers (Moleele *et al.* 2002), and goats may replace sheep and cattle as the primary livestock when this woody encroachment occurs (Palmer and Ainslie 2007). However, this process of woody encroachment is not restricted to communal lands, and there is abundant evidence of this type of degradation on freehold land (Lloyd *et al.* 2002, Bennett *et al.* 2012). While land-use plays a role, degradation linked to woody encroachment cannot readily be dis-associated from several confounding dynamic climatic factors such as elevated [CO_2], increasing temperature and declining potential evapotranspiration (Eamus and Palmer 2007, Hoffman *et al.* 2011). Policies which include this carbon sequestration opportunity (Stringer *et al.* 2012) should be more fully explored within policy review.

On a positive note, degraded rangelands can be rehabilitated (Milton 1994, Ludwig and Tongway 1996) and invasive woody species from the Nama-karoo and fynbos biomes (e.g. *Pteronia incana, Chrysocoma ciliata, Elytropappus rhinocerotis, Euryops spp., Cliffortia spp.*) have been replaced by grasses using rest-burn-rest strategies which graziers can implement (Trollope 1973, 1974). The challenging part for graziers using the commons is that these rehabilitation approaches require the application of long-term (>5 years) co-operative agreements to rest the veld before the burn is applied, in addition to the post-burn resting period. A lack of cohesive agreement between users of the commons, as well as pressure to feed large herds, generally precludes the use of these rest-burn-rest actions. In addition, many livestock owners on common land are non-residents, with strong rural-urban linkages (Ainslie 2002), who are unable to attend community meetings. Usually, once degradation has occurred, the time scales involved to achieve the desired turn-around in species composition and control of water and nutrient flow across the landscape, also mitigate against maintaining agreed management actions. These complex social-ecological systems require the presence of governance mechanisms that are able to manipulate ecosystems and strictly regulate use of the grazing resource, and these mechanisms are seldom present in common property decision making systems. Un-cooperative community members, absentee livestock owners and the economic imperatives of people who have very little economic flexibility, when combined with rainfall uncertainty, mitigate against manipulative actions that require long time horizons. In recent years, the options for registering carbon sequestration credits against the invasive woody component has been muted (Stringer *et al* 2012), and this may further preclude the use of fire to restore the grass component of degraded rangelands.

In areas where biophysical conditions appear to arrest the rate of degradation (higher annual rainfall, acid soils, lower rainfall uncertainty), a rest-burn-rest programme can effect rehabilitation. However, higher rainfall sites are subjected to invasion by woody taxa (e.g. *Passerina, Elytropappus, Acacia, Leucosidea*) when fire has been excluded, and these results are less easy to control. Events that are suitable for controlling woody species are infrequent e.g. when meteorological condition of low atmospheric relative humidity, low vegetation, low soil moisture and a high flammable biomass concur, and require rapid and decisive collective response to achieve desired outcomes. Risk of fire escaping and damaging property further discourages the use of this approach in the complex management situations experienced on common property. Several case studies (Trollope 1980, Joubert *et al.* 2012) and long-term grazing trials (Riginos *et al.* 2012) have demonstrated that burning can be used to achieve end-points which favour cattle and sheep production . However, the application of these treatments often requires rapid, sustained, collective responses which are seldom possible without effective governance structures in place.

In a summary of the results of a comprehensive survey of degradation in South Africa, Meadows and Hoffman (2002) note that the degree of degradation correlates with the "percentage of the population unemployed, the average number of dependants per household and the economic production per capita, all of which are, of course, surrogates of the level of poverty in the district". These socio-economic conditions make it difficult for graziers on common property to use evidence-based ecological understanding of ecosystem function to manipulate vegetation to suit their objectives. Although there is evidence that rangeland perceived to be degraded can still deliver a wide range of good and services (Scholes 2009), these services seldom fit the economic objectives of commercial economic farming, namely quality animals, delivered in reliable quantities, on-time. Degraded rangelands are particularly vulnerable to vagaries of climatic variation, with increased uncertainty in annual production (Evans *et al.* 1997, Gillson and Hoffman 2007), as there is seldom enough biomass on reserve to deal with the fodder shortages during exceptional circumstances.

Cultivation and abandonment as a driver of rangeland degradation

Kakembo and Rowntree (2003) and Vetter (2007) have demonstrated that abandonment of marginal cultivated land in semi-arid regions is an important driver of degradation, and we agree that degradation should not be blamed solely on excessive livestock herbivory. This argument is further developed by Vetter (2013). The cessation of stewardship actions associated with cultivation, e.g. maintenance of terraces, clearing of invasive weeds, filling of erosion gullies and the planting of suitable grasses along contour banks, exacerbates degradation with abandonment. As rangelands in communal areas usually incorporate all components of the landscape (e.g. areas around homesteads, cultivated lands, abandoned cultivated lands, riparian zone, road verges, and natural rangeland), degradation associated with abandonment and changes in the stewardship regime will affect the production potential for livestock.

Conclusion

Rangelands under common management in South Africa continue to experience transformation as defined by changes in species composition, structure and productivity. These changes are regularly accompanied by increased run-off and accelerated soil erosion, all of which have negative consequences to net primary production. In some situations, where edaphic variables contrive to maintain high basal vegetation cover (e.g. in coastal grasslands), these changes appear less deleterious to the production goals of graziers. However, in other regions such as highland grasslands, the Nama-karoo and lowlands of the succulent karoo, the consequences of excessive, continuous herbivory are more damaging to the resource, and result in dysfunctional landscapes with high run-off, accompanied by excessive water and nutrient loss. Clearly, the intervention instruments available to government to prevent further degradation and maintain resource condition on recently redistributed land need to be revisited.

Currently, the formal instrument for rangeland resource protection in South Africa is the Conservation of Agricultural Resources Act (Act 23 of 1983), also known as CARA. One principle of CARA is resource protection, and it provides the conduit for financial support in the form of drought subsidy to graziers that comply with the carrying capacity norms set down by the Department of Agriculture, Forestry and Fisheries (DAFF). The participating farmers have to demonstrate that they are within the regulated carrying capacity norm in order to qualify for inclusion in the programme, and only then are they eligible for relief during exceptional circumstances. In 1994, when a new democratic government was elected, there was a shift towards supporting developing farmers in communal areas. However, the regulations supporting CARA could not readily be adapted to areas under common tenure, where the resource was already perceived to be degraded. The Department of Agriculture, Forestry and Fisheries was unable to use the instrument available to it without facing legal challenges from those farmers whose land was in good condition.

In addition, pre-1994, there had been no effort to establish carrying capacity norms in the former homelands, as they were regarded as outside the Republic of South Africa. Without tested models of net primary production, placing constraints on herd size and regulating land under communal tenure, proved to be almost impossible. Although DAFF does currently provide support during exceptional circumstances to both commercial and communal livestock farmers, the mechanisms embedded in CARA are not appropriate for communal graziers. One of the main reasons for this is the poor collaboration from livestock owners in communities where they are either absent or reluctant to be dictated to by a committee or traditional authority.

More effort is required by government to prevent further degradation of new "communal" lands which are part of the land redistribution programme, and to provide support for governance structures that underpin decision-making. Since 1994, DAFF and provincial Departments of Agriculture have continued to allocate funds for the construction and maintenance of infra-structure such as fences and water-points, and this must be applauded, but DAFF does not support governance initiatives which would enhance community understanding of degradation processes and improve success of rehabilitation efforts. The norms required to implement CARA in the former homelands also need to be established if the principles of the Act are going to be applied. In addition, effective resource monitoring, including veld condition surveys, soil erosion monitoring, assessments of the threat of invasive alien plants and woody plant encroachment must be strengthened to provide objective reporting on the results of interventions.

Figure 1. A MODIS leaf area index (LAI) image (January 1, 2009) showing the extreme difference between adjacent quaternary catchments (S20C and S50E) in communal rangelands in the former Transkei, South Africa. The dark brown to yellow pixels in catchment S20C are low LAI values, and the light green to dark green pixels are high LAI values. The mean point-to-tuft distance (PTD) for perennial grasses in S20C (PTD=5.02 cm), was much greater than in S50E (PTD=1.13 cm). Both catchments have been subjected to the same communal management regimes (high stock numbers and continuous grazing) for >70 yrs and these differences in green biomass are most likely due to differences in the underlying lithology.

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